Conclusions: The quantitative features of 3D WE DESS images are different between subjects with pain and those that will not develop symptomatic pain. Furthermore, the lack of signal contrast between cartilage and surrounding tissue as well as the presence of abnormal cartilage thickness in the patella and abnormal bone shape (curvature) are strong predictors the imminent onset of frequent knee pain. Based on these results it is possible to use qMRI to select patients that will develop chronic pain in the next year.

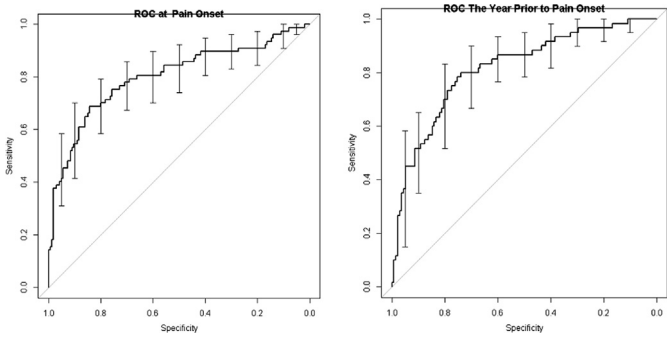

Fig. 1. Receiver operative curve (ROC) for the models that separates cases-and-controls. Left. discriminant model at the lime of recoding pain symptoms on most days for the lust 12 months. Right, model ROC of the year prior to recording the symptomatic pain.

462
NEW SOFTWARE METHOD TO QUANTIFY EFFUSION-SYNOVITIS IN OSTEOARTHRITIS OF THE KNEE

R.L. Russell †, S. Pandey †, K. Kwoh ‡, M. Hannon §, J. Grago §, A. Guermazi ||, F. Roemer ¶, M. Jarraya ||, C. Ratzlaff †, D. Hunter #, S. Smith †, J. Duryea †. † *Brigham and Women's Hosp., Boston, MA;* ‡ *Univ. of Arizona, Tucson, AZ;* § *Univ. of Pittsburgh and Pittsburgh VAHS, Pittsburgh, PA;* || *Boston Univ. Sch. of Med., Boston, MA;* ¶ *Univ. of Erlangen, Erlangen, Germany;* # *Univ. of Sydney, New South Wales, Australia*

Purpose: Effusion-synovitis of the knee, the collection of excessive fluid in the joint, is a common feature of OA and can be visualized with MRI. Several studies have documented semi-quantitative and quantitative methods for assessing this feature in the knee. Automated image processing software methods have been developed to measure cartilage, bone marrow lesions, and osteophytes, however these techniques have not been employed for effusion-synovitis. A quantitative measure of effusion-synovitis volume is potentially more objective and responsive to change in longitudinal studies. The goal of the present study was to document and provide criterion validation for a semi-automated, software method to measure effusion-synovitis of the knee in OA.
Methods: Forty subjects were selected from the Osteoarthritis Initiative (OAI), a multicenter cohort of 4796 participants with or at risk for knee OA. Axial 3T DESS MRI images of the knee were analyzed. A software technique using a thresholding algorithm was used to highlight areas of increased signal intensity. From the highlighted region, a reader selected areas corresponding to synovial fluid on all slices, which were summed to produce the volume measurement. The reading time per knee was also recorded. The correspondence between the MOAKS score and the quantitative assessment was measuring using Spearman's rank correlation.
Results: Patients had an average age of 65.8 years at baseline, and 50% were female, and an average BMI of 29.0 at baseline. Figure 1 is a graph of the software-determined total effusion-synovitis volume versus the MOAKS score. The MOAKS score was distributed as follows: 0: n = 2, 1: n = 10, 2: n = 18, 3: n = 10. The method was efficient, requiring less than 10 minutes per knee. Effusion-synovitis volume by quantitative assessment correlated moderately with MOAKS effusion-synovitis scores (r = .57). The ANOVA used to test for differences in mean volume by MOAKS levels was significant (p = .0004). Using the Tukey method, all pair-wise comparisons were significant at $p < .05$ except those involving MOAKS = 0, (n = 2) and the difference between MOAKS 1 and 2.
Conclusions: We have documented a semi-automated software method for measuring the volume of effusion-synovitis in patients with OA of the knee, and provided evidence of critrion validity through comparison with the a current standard for scoring effusion, MOAKS. Effusion-synovitis volume correlated moderately with MOAKS score

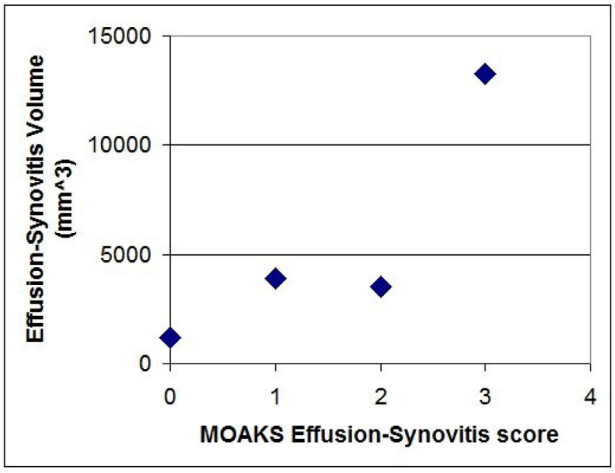

Fig. 1. Graph of the effusion volume as a function of MOAKS Hoff a-synovitis grade.

and we found little difference in volume between MOAKS scores of 1 and 2. This could be due to our limited sample size or to differences in slice selection compared to MOAKS scoring. Future studies with a larger sample size will clarify our results. To our knowledge this is the first automated image processing method to measure effusion-synovitis of the OA knee. An efficient and quantitative measure of this feature in knee OA has the potential to increase objectivity and responsiveness and decrease reader time in trials and large cohort studies, all of which could impact study power and cost.

463
QUANTITATIVE MEASUREMENT OF HOFFA-SYNOVITIS: VALIDATION OF A NEW SOFTWARE METHOD

S. Pandey †, R.L. Russell †, K. Kwoh ‡, M. Hannon §, J. Grago §, A. Guermazi ||, F. Roemer ¶, M. Jarraya ||, C. Ratzlaff †, D. Hunter #, S. Smith †, J. Duryea †. † *Brigham and Women's Hosp., Boston, MA;* ‡ *Univ. of Arizona, Tucson, AZ;* § *Univ. of Pittsburgh and Pittsburgh VAHS, Pittsburgh, PA;* || *Boston Univ. Sch. of Med., Boston, MA;* ¶ *Univ. of Erlangen, Erlangen, Germany;* # *Univ. of Sydney, New South Wales, Australia*

Purpose: Hoffa-synovitis can be seen in impingement or friction syndromes as well as patellar maltracking. It is also used as a sensitive but not specific surrogate MRI marker for synovitis in OA. Indeed several studies have described qualitative approaches for measuring Hoffa-synovitis in OA. A quantitative measure for Hoffa-synovitis not currently available, but may provide unique information and potentially be sensitive to change.

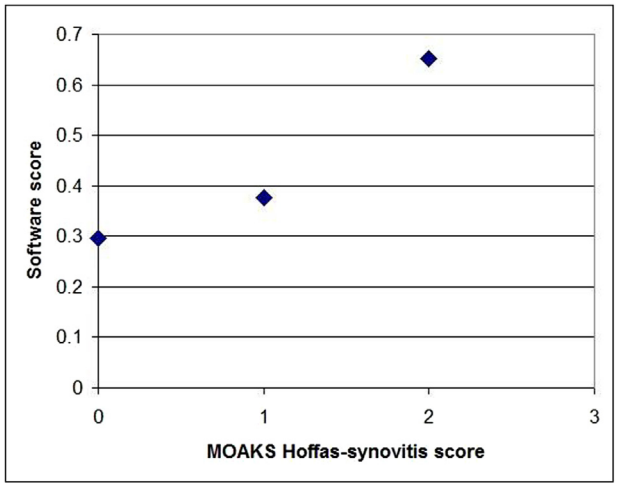

Fig. Graph. of the Software Score as a function of MOAKS Hoffa-synovitis grade.

The goal of our study is to describe a quantitative software-based semi-automated method to characterize Hoffa-synovitis.

Methods: Forty subjects were selected from the Osteoarthritis Initiative (OAI), a multicenter cohort of 4796 participants with or at risk for knee osteoarthritis (OA). Sagittal 3T TSE intermediated-weighted fat-suppressed (Iw FS) MRI of the knee were evaluated. A software method was used to characterize the regions of infrapatellar Hoffa's fat pad edema (surrogate for synovitis) on each slice. As an initial step, a center slice was defined as the location of the midportion of the ACL. The reader drew a region of interest delineating Hoffa's fat pad using an average of 8 slices medial and lateral to the patellar tendon to include the anatomy of the infrapatellar Hoffa's fat pad. The software automatically applied a quantitative algorithm on each image to detect signal associated with Hoffa-synovitis and produce an aggrate Software score for the entire scan. The software method was compared to the MRI Osteoarthritis Knee Score (MOAKS) Hoffa-synovitis score. The correspondence between the MOAKS score and the quantitative assessment was measuring using Spearman's rank correlation.

Results: Patients had an average age of 65.8 years at baseline, and 50% were female, with an average BMI of 29.0 at baseline. Following the short reader training, the software method was efficient, requiring less than 5 minutes per knee of reader time. Figure 1 provides a graph of the average Software score as a function of the MOAKS grade. The MOAKS score were distributed as follows: 0: $n = 5$, 1: $n = 22$, 2: $n = 13$. The quantitative synovitis measurement correlated moderately with MOAKS synovitis scores ($r = .51$). An ANOVA used to test for differences in mean measurements by MOAKS level was significant ($p = .0008$). Using the Tukey method, pair-wise comparisons all levels except 0 and 1 were significant at $p < .05$.

Conclusions: To our knowledge, this is the first study that describes a fully quantitative software tool to quantify Hoffa-synovitis. This method can potentially increase objectivity, accuracy and responsiveness. Once the measurement is fully validated, it will be feasible to provide a measurement for a large number of knees.

464
CROSS-SECTIONAL AND LONGITUDINAL RELIABILITY OF SEMIQUANTITATIVE OSTEOARTHRITIS ASSESSMENT AT 1.0T EXTREMITY MRI: MULTI-READER DATA FROM THE MOST STUDY

F.W. Roemer †, M. Nevitt ‡, D. Felson †, M.D. Crema †, M.D. Marra †, J. Niu †, J.A. Lynch ‡, I. Tolstykh ‡, C. Lewis §, J. Torner ‖, A. Guermazi †. † *Boston Univ. Sch. of Med., Boston, MA;* ‡ *UCSF, San Francisco, CA;* § *Univ. of Alabama at Birmingham, Birmingham, AL;* ‖ *Univ. of Iowa, Iowa City, IA*

Purpose: Several large epidemiologic osteoarthritis (OA) studies including magnetic resonance imaging (MRI) are currently ongoing. A large proportion of these MRI datasets is being assessed in semi-quantitative fashion by expert radiologist readers using validated scoring instruments. While cross-sectional reliability results between two trained and calibrated readers has been presented for all MRI scoring systems, data on longitudinal reliability in regard to detection of change over time has not been presented to date. In order to facilitate and accelerate assessment more than two radiologists may be assessing MRI datasets simultaneously. For meaningful data interpretation it is paramount to ensure reliability between all readers.

Aim of this study was to determine reliability between four different readers in cross-sectional and longitudinal fashion in the MOST study using the modified whole organ magnetic resonance imaging score (WORMS).

Methods: The Multicenter Osteoarthritis (MOST) study is a longitudinal cohort study of subjects with or at high risk of knee OA. 10 subjects were

Table1. Cross-sectional and longitudinal reliability for substudy A (60 and 84 months readings, n = 10)

MRI Feature	Category	R01 vs. R02	R01 vs. R03	R01 vs. R04	R02 vs. R03	R02 vs. RCU	R03 vs. R04
Cartilage morphology	Cross-sectional	0.85 (0.81–0.90)	0.86 (0.82–0.90)	0.82 (0.77–0.87)	0.77 (0.71–0.82)	0.79 (0.73–0.84)	0.87 (0.82–0.91)
	Longitudinal	0.78 (0.67–0.90)	0.77 (0.66–0.88)	0.63 (0.49–0.77)	0.63 (0.46–0.77)	0.62 (0.46–0.77)	0.70 (0.56–0.84)
Osteophytes	Cross-sectional	0.64 (0.57–0.72)	0.52 (0.46–0.59)	0.47 (0.40–0.54)	0.49 (0.42–0.56)	0.48 (0.41–0.55)	0.80 (0.76–0.84)
	Longitudinal	0.61 (0.47–0.75)	0.58 (0.43–0.72)	0.54 (0.40–0.69)	0.48 (0.33–0.64)	0.43 (0.27–0.58)	0.76 (0.66–0.86)
Bone marrow lesion	Cross-sectional	0.89 (0.84–0.94)	0.81 (0.74–0.88)	0.81 (0.74–0.88)	0.80 (0.74–0.87)	0.83 (0.76–0.90)	0.86 (0.81–0.92)
	Longitudinal	0.88 (0.80–0.96)	0.82 (0.73–0.92)	0.80 (0.70–0.91)	0.75 (0.63–0.87)	0.79 (0.68–0.91)	0.80 (0.69–0.91)
Subchondral cysts	Cross-sectional	0.68 (0.46–0.90)	0.54 (0.32–0.77)	0.50 (0.27–0.72)	0.51 (0.29–0.73)	0.48 (0.26–0.69)	0.93 (0.82–1.00)
	Longitudinal	0.60 (0.23–0.97)	0.70 (0.39–1.00)	0.70 (0.39–1.00)	0.60 (0.29–0.91)	0.60 (0.29–0.91)	1.00 (1.03–1.00)
Bone attrition	Cross-sectional	0.79 (0.70–0.89)	0.76 (0.69–0.83)	0.71 (0.53–0.80)	0.79 (0.70–0.88)	0.80 (0.70–0.89)	0.88 (0.80–0.95)
	Longitudinal	0.71 (0.48–0.95)	0.67 (0.46–0.88)	0.61 (0.88–0.83)	0.51 (0.24–0.78)	0.55 (0.28–0.82)	0.77 (0.58–0.97)
Meniscal tears	Cross-sectional	0.94 (0.90–0.98)	0.92 (0.88–0.97)	0.92 (0.87–0.97)	0.97 (0.93–1.00)	0.92 (0.87–0.98)	0.96 (0.92–0.99)
	Longitudinal	0.92 (0.81–1.00)	0.84 (0.68–1.00)	0.75 (0.55–0.95)	0.91 (0.79–1.00)	0.81 (0.63–1.00)	0.89 (0.73–1.00)
Menisci extrusion	Cross-sectional	0.83 (0.69–0.98)	0.82 (0.67–0.97)	0.86 (0.72–1.00)	0.71 (0.52–0.90)	0.67 (0.45–0.88)	0.81 (0.65–0.97)
	Longitudinal	0.81 (0.62–1.00)	0.75 (0.55–0.95)	0.95 (0.87–1.00)	0.67 (0.42–0.91)	0.77 (0.57–0 96)	0.81 (0.60–1 00)
Hoffa–synovitis	Cross-sectional	0.60 (0.38–0.83)	0.58 (0.36–0.80)	0.45 (0.24–0.66)	0.16 (0.10–0.42)	0.24 (–0.04–0.52)	0.59 (0.350.82)
	Longitudinal	0.64 (0.00–1.00)	0.44 (–0.21–1.00)	0.31 (0.27–0.90)	0.64 (0.00–1.00)	0.45 (–0.15–1.00)	0.77 (0.35–1.00)
Effusion-synovitis	Cross-sectional	0.89 (0.75–1.00)	0.88 (0.72–1.00)	0.72 (051–0.92)	0.78 (0.56–0.99)	0.62 (0.40–0.84)	0.57 (0.32–0.82)
	Longitudinal	0.85 (0.57–1.00)	0.64 (0.28–1.00)	0.85 (0.57–1.00)	0.47 (0.08–0.86)	0.70 (0.28–1.00)	0.47 (0.08–0.86)

Table 2
Cross -sectional and longitudinal reliability for substudy B (baseline, 60 and 84 months readings, n = 10).

90% MRI Feature	Category	R01 vs. R02	R01 vs. R03	R01 vs. R04	R02 vs. R03	R02 vs. 04	R03 vs. R04
Cartilage morphology	Cross-sectional	0.85 (0.81–0.89)	0.86 (0.81–0.9)	0.86 (0.82–0.9)	0.96 (0.95–0.98)	0.95 (0.93–0.97)	0.93 (0.90–0.95)
	Longitudinal	0.51 (0.41–0.61)	0.51 (0.41–0.61)	0.50 (0.41–0.60)	0.82 (0.76–0.88)	0.82 (0.75–0.89)	0.67 (0.59–0.75)
Osteophytes	Cross-sectional	0.92 (0.9–0.94)	0.93 (0.91–0.95)	0.93 (0.91–0.95)	0.94 (0.92–0.96)	0.94 (0.92–0.96)	0.95 (0.93–0.97)
	Longitudinal	0.56 (0.46–0.66)	0.55 (0.44–0.65)	0.49 (0.37–0.60)	0.71 (0.62–0.8)	0.60 (0.48–0.71)	0.65 (0.53–0.76)
Bone marrow lesion	Cross-sectional	0.86 (0.82–0.91)	0.85 (0.80–0.91)	0.93 (0.89–0.97)	0.89 (0.84–0.94)	0.85 (0.80–0.90)	0.86 (0.82–0.91)
	Longitudinal	0.8 (0.73–0.87)	0.71 (0.63–0.80)	0.88 (0.82–0.94)	0.77 (0.68–0.85)	0.76 (0.68–0.84)	0.80 (0.73–0.87)
Subchondral cysts	Cross-sectional	0.83 (0.69–0.96)	0.83 (0.69–0.96)	0.80(0.66–0.94)	1.00(1.00–1.00)	0.88 (0.77–0.98)	0.88 (0.77–0.98)
	Longitudinal	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	1.00 (1.00–1.00)	0.50 (0.07–0.92)	0.50 (0.07–0.92)
Bone attrifion	Cross-sectional	0.87 (0.77–0.96)	0.94 (0.88–1.00)	0.96(0.92–1.00)	0.92(0.84–1.00)	0.87 (0.78–0.96)	0.91 (0.83–0.98)
	Longitudinal	0.66 (0.35–0.97)	0.80 (0.52–1.00)	0.66 (0.35–0.97)	0.56 (0.25–0.88)	0.75 (0.50–0.99)	0.56 (0.25–0.88)
Meniscal tears	Cross-sectional	0.94 (0.90–0.98)	0.95 (0.91–0.99)	0.89 (0.83–0.95)	0.97 (0.94–0.99)	0.95 (0.90–0.99)	0.91 (0.86–0.97)
	Longitudinal	0.80 (0.64–0.95)	0.80 (0.64–0.96)	0.56 (0.35–0.76)	0.92 (0.83–1.00)	0.79 (0.65–0.93)	0.70 (0.55–0.85)
Meniscal extrusion	Cross-sectional	0.79 (0.64–0.93)	0.75 (0.60–0.90)	0.72 (0.57–0.87)	0.9 (0.80–1.00)	0.93 (0.84–1.00)	0.89 (0.79–1.00)
	Longitudinal	0.42 (0.09–0.75)	0.13 (–0.17–0.44)	0.19 (–0.14–0.53)	0.57 (0.26–0.88)	0.84 (0.62–1.00)	0.52 (0.18–0.85)
Hoffa– synovitis	Cross-sectional	0.76 (0.62–0.9)	0.76 (0.62–0.90)	0.73 (0.58–0.88)	1.00 (1.00–1.00)	0.97 (0.91–1.00)	0.97 (0.91–1.00)
	Longitudinal	0.39 (0.12–0.66)	0.39 (0.12–0.66)	0.21 (–0.03–0.45)	1.00 (1.00–1.00)	0.65 (0.21–1.00)	0.65 (0.20–1.00)
Effusion–synovitis	Cross-sectional	0.76 (0.60–0.93)	0.71(0.55–0.88)	0.66 (0.46–0.87)	0.88 (0.73–1.00)	0.96 (0.88–1.00)	0.89 (0.75–1.00)
	Longitudinal	0.51 (0.28–0.75)	0.54(0.31–0.77)	0.37 (0.11–0.64)	0.70 (0.36–1.00)	0.82 (0.57–1.00)	0.59 (0.20–0.97)